Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (ATSA SURF IA) Application Description

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Working Group 1
Sub Group ATSA SURF IA

This is not the final version of the document and has not been approved by the SC 186-plenary committee

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Abstract

This document outlines the initial flight deck-based application Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts (ATSA SURF[1] IA). This application provides flight crews with alerts and indications about traffic related safety hazards on the airport surface. ATSA SURF Indications are intended to facilitate pilot awareness of the situation by identifying the runway traffic status as relevant to own-ship operations under normal operational conditions. ATSA SURF Alerts are intended to attract the attention of the flight crew to a non-normal operational condition in a timely manner. The document outlines the concept, roles, responsibilities, and functional requirements for ATSA SURF IA. The described application is currently at the beginning of a consensus based definition process that includes government and industry stakeholder organizations as part of RTCA, SC-186, Working Group 1. The objective is the development of requirements and guidelines for universal flight deck-based alerting and indication of actual or potential traffic conflicts to avoid surface and near surface traffic collision hazards for general aviation and commercial operators.

The described application builds on and extends existing application descriptions. Specifically, the Airport Surface Situational Awareness (ASSA) and Final Approach and Runway Occupancy Awareness (FAROA) applications (RTCA / DO-289) that describe requirements for electronic maps and traffic displays are basic building blocks. However, alerting and indication requirements are also specified for conditions when no traffic or map displays are available on the flight-deck and flight crews may initiate responses based solely on ATSA SURF alerts. The described application is intended for implementation in the relative short term over a few years but also considers later development phases.

[1] ATSA SURF is the name of an application description that is currently being defined by the requirement focus group (RFG), an international body consisting of members from RTCA, FAA, Eurocontrol, and EUROCAE. The ATSA SURF IA application builds on the ATSA SURF application description.

Table of Contents

1 Introduction

This document describes an application for providing traffic safety alerts and other information directly to the flight deck. This application is termed Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerting (ATSA SURF IA). The document is intended as an addendum to existing RTCA document DO-289 (RTCA 2003) where the application of ADS-B for the display of traffic information on cockpit displays is described. ATSA SURF IA is also applicable to conditions where no Cockpit Display of Traffic Information (CDTI) is present. The initial version of this application is essentially independent of a ground based system so that e.g. no safety critical information is required to be uplinked from a ground based system to the flight deck. Future versions of this application may integrate the uplink of ground-based information. Other implementation alternatives that are excluded from this initial version are listed in Section 7.

1.1 Background

Airport surface operations include the movement of aircraft and ground vehicles such as snow plows or personnel transport vehicles. At airports with air traffic control (ATC) towers, traffic movement in the active movement areas around taxiways and runways are controlled by ATC during hours of operations. Airport surface movement in non-movement areas, (e.g. around ramp areas that are close to the airport terminal) may be controlled by airline operated ramp towers that provide control from the gate to the active movement area. At non-towered airports, pilots coordinate airport and runway usage via radio communication among themselves and/or fixed based operators.

During current airport surface operations, flight crews navigate the airport surface via their self-determined or ATC assigned taxi route using either a paper map or electronic map display and airport visual aids. If assigned by ATC, taxi route information is communicated verbally to flight crews via radio. Out-the-window visual aids on runways and taxiways include centerlines, edge lines, airport surface lights and signage, other aircraft and vehicles, terrain, buildings, taxiways, runways, etc.

Runway incursions (RIs) at towered airports in the United States (US) have been a major area of concern for the U.S. National Airspace System (NAS) for the past several years. ICAO and FAA both define a runway incursion as any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take off of aircraft. The NAS has approximately 500 Federal Aviation Administration (FAA)/contract towered airports that handle about 176,000 arrivals and departures per day. Of the approximately 257 million operations at US towered airports from Fiscal Year (FY) 2001 through FY 2004, there were 1,395 runway incursions. That is an average of approximately one incursion per day during the four year period (FAA, 2005a).

In the US, the FAA has initiated several programs to increase runway safety:

- Standards for airport surface markings have been updated to improve markings in the hold-short environment (FAA Advisory Circular – AC 150/5340-1J, FAA, 2006a).
- A runway status light system has been developed to provide pilots with information about current or immediately anticipated runway occupancy (FAA 2007a). The runway status light system consists of runway entrance lights (REL) for the runway entrance and take-off hold lights (THL) for take-off situations. That system has been tested at Dallas Fort Worth International Airport (DFW) and at San Diego-Lindbergh Field (SAN).
- The Airport Movement Area Safety System (AMASS) has been developed to provide air traffic controllers with alerts about potential collisions between aircraft (FAA 2005b). The system has encountered some limitations in usability under certain conditions that are also due to the ground surveillance technology. A new system has been developed to address some of these limitations, see below.
- The Airport Surface Detection Equipment, model X (ASDE-X) was developed to provide an electronic display of aircraft movement and safety alerting functionality to the air traffic control tower and replace some of the ASDE3/AMASS systems (FAA 2006b). This system is projected to be deployed at 35 airports and is intended to provide situation awareness and alerting functions to air traffic controllers.
- New airport designs are directed to reduce the likelihood of creating areas that could cause runway incursions. This is done by, for example, reducing large expanses of concrete and by reducing the number of runway crossings which have been large contributors to runway incursions.
- Similarly, some airports are retrofitted with end around taxiways (EAT) to allow aircraft to taxi around runways instead of crossing them.
- The FAA has initiated a Runway Incursion Information Evaluation Program (RIIEP) to learn more about runway safety hazards. This program provides pilots who are involved in runway incursions some protection against legal action if they provide information to aviation safety inspectors.
- Flight decks have started to be equipped with moving maps. Also, standards for the CDTI are currently being developed. Due to CDTI range constraints, the effectiveness of CDTI’s to enhance flight crew’s situation awareness has been so far limited as situation awareness tool. New designs are addressing this deficiency and are incorporating map range selections suitable for ground operations to aid situation awareness about the airport surface and traffic.
- The FAA is providing guidance to airlines about standardizing ground operations in AC 120-74A (FAA, 2003a) for flight crews and in AC 91-73 (FAA, 2003b) for single pilot operations.
- FAA and pilot associations are providing training and education about runway safety to pilots in various formats including workshops, websites, and DVDs.

International efforts include the development of an Advanced Surface Movement Control Guidance System (A-SMCGS) that provides surface traffic management, guidance, and alerting functionality to ATC and pilots (see IFATCA 2003). Thereby, European countries focus on alert implementations for controllers whereas alerting for the flight deck has not yet been defined in much detail.

Despite these efforts, runway incursions have continued to occur. The National Transportation Safety Board (NTSB) has recommended the development of a ground movement safety system with direct pilot warning capabilities (NTSB 2000). The recommendation states:

> *Require, at all airports with scheduled passenger service, a ground movement safety system that will prevent runway incursions; the system should provide a direct warning capability to flight crews. In addition, demonstrate through computer simulations or other means that the system will, in fact, prevent incursions. (A-00-66 2000).*

There is general agreement that the main causal factors contributing to RIs are related to human behavior (e.g., Cardosi & Yost, 2000; FAA 1998). Specifically, Adam & Kelley (1996) surveyed 1437 pilots from two commercial airlines and interviewed a subgroup of them to identify causal factors for RIs (see also Adam, Kelley & Steinbacher, 1994). Various causal factors contribute to runway incursions: The first group of causal factors is related to airport characteristics such as signage, markings, lighting, runway geometry, as well as lack of familiarity of pilots with the airport surface and procedures. Another group of causal factors is related to the communication of control clearances via auditory communication channel which frequently represents an information bottleneck under stress conditions. Errors can be caused by both pilots, controllers (see e.g., Bales, Gillan & King, 1989 and Steinbacher, 1991), or surface vehicle operators.
The causal factors leading to runway incursions and collisions may be addressed in multiple ways as was outlined above. The approach that is described in this document is to (1) decrease the likelihood of safety critical errors occurring during airport surface operations by increasing the likelihood that pilots notice runway safety relevant information, (2) to provide runway safety relevant information in a timely, real-time manner, and (3), to support flight crew recovery once an error has occurred by alerting them about an impending safety hazard.

1.2 Operational purpose

The operational purpose of this document is to describe the concept, roles, responsibilities and functional requirements for universal[2] flight deck-based alerting and indication of actual or potential traffic conflicts to avoid surface and near surface traffic collision hazards for general aviation and commercial operators.
The ATSA SURF IA application builds on existing application descriptions that are described in RTCA document DO-289 (RTCA, 2003). The Airport Surface Situational Awareness (ASSA) application is flight deck-based and includes the depiction of own-ship position and traffic position on a surface moving map that includes runways, taxiways, holding areas, ramps, hangars, and prominent airport structures. The ASSA application may be hosted on a multifunctional display, a dedicated display, a head-up display, or an electronic flight bag display. The flight crew may use this display to identify traffic positions relative to own-ship and may observe traffic movement.
The Final Approach and Runway Occupancy Awareness (FAROA, see DO-289, RTCA, 2003) application provides information about runway occupancy to the flight crew on approach and is a

[2] Assumes appropriate flight deck equipage or ground infrastructure where flight deck equipage is not appropriate.

subset of the ASSA application. The FAROA application displays only the runway layout without other airport layout details such as taxiways or ramp areas. Neither the ASSA nor the FAROA applications provide active alerts to pilots. Both applications, ASSA and FAROA have been incorporated into the ATSA SURF concept by an international standard development group, the Requirement Focus Group (RFG) (RFG 2006). ATSA SURF is currently a separate application from ATSA SURF IA but both applications are intended to be eventually combined.

Flight crews will use ATSA SURF indications and alerts in combination with other information inside or outside the cockpit to obtain traffic situation awareness and determine the appropriate course of action. In addition, ATSA SURF alerts are designed to be sufficient for an immediate flight crew response and may be used as sole mean for response initiation. In this sense the ATSA SURF IA application goes beyond a pure situational awareness application and may require higher surveillance standards.

1.3 Domain / Environment

The ATSA SURF IA application will be available at all airports with a suitable airport database and not require specific airport ground infrastructure. If infrastructure is available at the airport to provide ADS-B coverage, this ground infrastructure will be used. The ATSA SURF IA application is expected to be utilized by all types of aircraft and vehicles operating in the NAS (e.g. including military, general aviation, commercial carriers) at both controlled as well as uncontrolled airports. The covered volume of airspace includes approach and departure zones up to the altitude of approximately 1000 feet above touchdown where existing collision avoidance systems such as TCAS do not provide resolution advisories. The application will include all available data, including air-to-air ADS-B and ground-to-air TIS-B data. The application will not require surface surveillance radar, such as ASDE-X. The ATSA SURF IA application provides indications and alerting under all visibility and weather conditions. Integration of ATSA SURF indications and alerts with existing cockpit alerting systems is to be determined. Also, the interaction with existing or new ground-based alerting capabilities needs to be determined for future versions of this concept.

1.4 Maturity and user interest

As runway safety is a continuing high priority item in the NAS, a direct pilot alerting capability is expected to reduce the likelihood of runway collisions and is of high interest to the aviation community. Such a capability has been recommended by the NTSB in its most wanted recommendations for the FAA and has been quoted above. Also, the FAA has initiated ADS-B implementation to provide ADS-B services in the NAS starting at around 2010. Various research and development activities on flight deck-based airport surface safety systems have been conducted, e.g. Jones (2002, 2005), Jones and Prinzel (2006), Jones, Quach, Young, (2001), Young & Jones (2000), Cassell, Evers, Esche, & Sleep (2002, 2003), Hyer (2002), Hooey, Foyle, & Andre (2000), Hooey, Foyle, Andre & Parke (2000), Young & Jones (2001). For implementation of an alerting capability on or near the airport surface, the definition of a generally accepted standard is now needed.

2 Operational concept, roles, and procedures

This section is in an early stage of the development and will receive significant refinement during the concept maturation.

2.1. Concept description

This section describes the concept of operations for the generation of ATSA SURF IA indications and alerts to the flight deck.

ATSA SURF IA - alerts and indications are provided to enhance flight crew traffic awareness and to avoid actual and potential high speed conflicts on or near the airport surface. The terms alerts and indications are defined in Section 8 and are consistent with regulatory guidance (see draft AC 25.1322, FAA, 2007c).

The ATSA SURF IA application provides traffic related indications and alerts respectively for different types of normal and non-normal scenarios associated with potential or actual runway conflicts. The term "scenario" is here used to describe a sequence of aircraft movement between at least two aircraft[3]. Scenarios are "runway safety scenarios" if the movement between two aircraft/vehicles could potentially result in a collision between at least two aircraft. Aircraft movement is categorized here into five discrete aircraft states:

A. Entering or crossing the runway: An aircraft or vehicle is moving toward the runway, is anticipated to potentially enter the runway, and therefore causes a potential conflict.
B. Departure: An aircraft is departing, moving at a speed above taxi speed, e.g., 35 knots. The departure state is further distinguished into two substates[4]:
    a. Above taxi speed and below lift-off
    b. After lift-off until approx. 1000 feet altitude AGL
C. Approach to runway: An aircraft is lined up with the arrival runway and at or less than 3 NM from the arrival threshold and has not yet touched down.
D. Landing: An aircraft has touched down and is moving at a speed above taxi speed, e.g., 35 knots
E. Stopped or taxiing on runway: An aircraft or vehicle is currently on a runway in a low energy state, i.e., either stopped or taxiing.

These aircraft states can occur on following set of runway constellations:

- Single runway
- Closely spaced parallel runway[5]
- Intersecting runways

[3] Though vehicles are not specifically mentioned here, also vehicles could cause these conflicts.
[4] Departure mode may be determined using aircraft speed or other means, e.g. throttle position, if available.
[5] Closely spaced parallel runways are included here because movement on such runways can lead very quickly to a runway safety scenario. This could be, for example, the case when a landed aircraft were to turn quickly off from one runway and inadvertently crossed a closely spaced parallel runway.

The universe of all feasible arrangements of states between two aircraft is listed in Table 1 that consists of 107 entries. These aircraft states are therefore the building blocks for runway incursion scenarios. The connection between aircraft states, runway constellations, and runway incursion scenarios is outlined in Figure 1[6]. Note that not all aircraft state arrangement may lead to runway incursion scenarios. They are included nonetheless to provide a complete problem description.

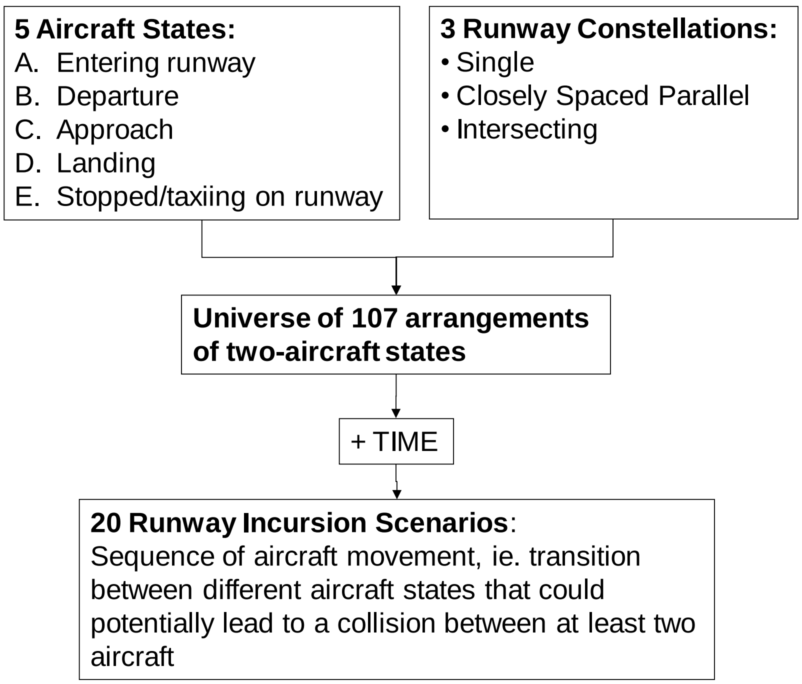

Figure 1 Runway Incursion Scenario Construction Process

[6] There are several ways how runway incursion scenarios may be constructed. Specifically, a “historic” approach could be used that utilizes records of previous runway incursion incidents to select scenarios that are candidates for indications and alerts. Such approach has the disadvantage that only known safety scenarios are included and that other, not yet historically occurred scenarios may not be covered. A different approach is therefore used here that starts with a principled analytic solution from all possible (and feasible) aircraft states to derive runway safety scenarios.

Table 1 Universe of Possible Two-Aircraft State Arrangements for Runway Incursion Scenarios.

		Own-Ship (OS) States				
		A. Taxiing to Enter Runway	**B. Departure**	**C. Approach to Runway (<= 3 NM from rwy)**	**D. After Landing, Roll-out on Runway**	**E. Stopped or Taxiing on Runway**
Other Aircraft / Obstacle / Vehicle (T) States	**Taxiing to enter same runway**	1	17: T Ahead 18: T Behind	38: T Ahead 39: T Behind	58: T Ahead 59: T Behind	80: T Ahead 81: T Behind
	Departure from same runway	2 Converging 3 Diverging	19: T Ahead 20: T Behind 21: T Head on	40: T Ahead 41: T Behind 42:T Head on	60: T Ahead 61: T Behind 62: T Head on	Ownship lined up: 82: T Ahead 83: T Behind 84: T Head on Ownship crossing: 85 Behind T 86 ahead of T
	Approach to same runway	4 Converging	22: T Behind 23: T Head on	43: T Ahead 44: T Behind 45: T Head on	63: T Ahead 64: T Behind 65: T Head on	Ownship lined up: 87: T Ahead 88: T Behind 89: T Head on Ownship crossing: 90: behind T 91: ahead of T
	Landing/rollout on same runway	5 Converging 6 Diverging	24: T Ahead 25: T Behind 26: T Head on	46: T Ahead 47: T Head on	66: T Ahead 67: T Behind 68: T Head on	Ownship lined up: 92: T Ahead 93: T Behind Ownship lined up against rwy dir. 94: T Head on 95: behind T 96: ahead of T
	Stopped or taxiing on same runway	7 Converging 8 Diverging	27: T Ahead 28: T Behind 29: T Head on	48: T Ahead 49: T Behind	69: T Ahead 70: T Behind 71: T Head on	97: T Ahead 98: T Behind 99: T Head on
	Approach to intersecting runway	9	30	50	72	100
	Landing/rollout intersecting rwy	10	31	51	73	101
	Departure on intersecting rwy	11	32	52	74	102
	Stopped/taxiing intersecting rwy	12	33	53	75	103
	Approach to parallel rwy	13	34	54	76	104
	Landing/rollout on parallel runway	14	35	55	77	105
	Departure on parallel runway	15	36	56	78	106
	Stopped/taxiing on parallel rwy	16	37	57	79	107

Note: T = Traffic other than ownship; Ahead = ahead of ownship, same direction as ownship; Head on = ahead of ownship and moving toward ownship

From the universe of two-aircraft arrangements in Table 1, the 5 types of 20 ATSA SURF IA runway safety scenarios are (the numbers in parenthesis refer to the aircraft state arrangements in table 1):

Type A Runway Incursion Scenarios: **Ownship taxies toward runway to enter runway**, and

1. Conflict traffic: approaches, lands, and taxies or stops on same runway (4 – 8)
2. Conflict traffic: taxies to enter same runway, enters the runway, then departs (1,7-8, 2-3)
3. Conflict traffic is on intersecting runway (9–12)
4. Conflict traffic is on parallel runway (13-16)

Type B Runway Incursion Scenarios: **Ownship departs**, and

5. Conflict traffic: taxies to enter same runway or is stopped /taxiing on the same runway (17-18, 27-29), and then departs from same runway (19-21)
6. Conflict traffic: approaches, lands, taxies and then stops on runway (22–29)
7. Conflict traffic is on intersecting runway (30–33)
8. Conflict traffic is on parallel runway (34-37)

Type C Runway Incursion Scenarios: **Ownship approaches runway**, and

9. Conflict traffic: taxies to enter same runway or is stopped /taxiing on the same runway (38-39,48-49) and then departs from same runway (40-42)
10. Conflict traffic: approaches, lands, taxies and then stops on runway (43-47)
11. Conflict traffic is on intersecting runway (50-53)
12. Conflict traffic is on parallel runway (54-57)

Type D Runway Incursion Scenarios: **Ownship has landed on runway**:

13. Conflict traffic: taxies to enter same runway or is stopped /taxiing on the same runway (58-60, 69-71), and then departs from same runway (61-62)
14. Conflict traffic: approaches, lands, taxies and then stops on runway (63-65, 66-71)
15. Conflict traffic is on intersecting runway (72-75)
16. Conflict traffic is on parallel runway (76-79)

Type E Runway Incursion Scenarios: **Ownship has stopped or is taxiing on runway**

17. Conflict traffic: taxies to enter same runway or is stopped /taxiing on the same runway (80-81,97-99), and then departs from same runway (82-86)
18. Conflict traffic: approaches, lands, taxies and then stops on runway (87-96)
19. Conflict traffic is on intersecting runway (100-103)
20. Conflict traffic is on parallel runway (104-107)

ATSA SURF IA indications, alerts or both may be triggered for these runway safety scenarios.

Next the principles for the presentation of ATSA SURF IA are described. The ATSA SURF indication and alert principles” are guiding rules concerning safety relevant information on the flight deck relative to the own-ship position and surrounding traffic. These principles are intended for guidance of the concept development. The principles will be updated to reflect actual decisions. Presentation requirements are indicated in Table 2, page 15.

2.1.1. Indication Principles

ATSA SURF indications facilitate pilot awareness and assessment of the situation by identifying the runway and traffic status as relevant to own-ship operations. Indications identify normal operational conditions to the flight crew that are generally relevant for runway safety but could be a precursor to a runway safety hazard. Indications contain information about current or predicted occupation or use of a runway as outlined below. One prerequisite for triggering indications is that own-ship enters a predefined area in relation to the runway. That means indications are triggered based on ownship and traffic time and distance to the runway. Two presentation principles are distinguished, a basic and a context dependent principle:

> *<u>Basic indication presentation principle</u>: Indications are presented for specific types of runway related occupancy and use as outlined below to ensure consistent presentation based on simple criteria.*
>
> *<u>Context dependent indication presentation principle</u>: Indications are presented context dependent based on the current state and position of the own-ship aircraft. For example, only traffic on a runway that ownship could be entering within a proximate distance is highlighted / indicated whereas traffic on a more distant runway is not indicated.*

Either one of these two indication presentation principles may be recommended for final use based on appropriate research findings. A design decision on this issue is outstanding.

In this document a runway is called in use when an aircraft is currently moving on that runway or is predicted to be moving on that runway at high speed (e.g. above 35 knots). A runway is called occupied when an aircraft is currently stopped or moving on that runway at low speed (e.g. at or below 35 knots).

<u>Types of runway and traffic indications:</u>

- Ownship runway occupied (during low energy operations, e.g. for aircraft stopped, taxiing, or crossing)
- Ownship runway in use (during high energy operations, e.g. for departures or landings)
- Crossing runway occupied or in use
- Closely spaced parallel runway occupied or in use
- Ownship runway or crossing / closely spaced runway predicted in use
- Ownship runway or crossing / closely spaced runway predicted to be occupied (this state may not trigger a "basic indication", but trigger only a "context dependent indication")

2.1.2. Alert Principles

ATSA SURF alerts are intended to help prevent potential collisions between two aircraft. ATSA SURF employs a two-level alerting scheme. The term *alert* is used in this document as a generic term to describe a flight deck annunciation meant to attract the attention of the flight crew to a non-normal operational or airplane systems condition. The alerting concept is being developed to be consistent with the regulatory guidance in draft AC 25.1322 (FAA 2007c) concerning flight deck alerting. AC 25.1322 defines three possible levels of alerting; advisory, caution, and warning. Each alert level is uniquely defined in terms of pilot awareness and action but it is not required for any particular system to employ all three levels of alert.

For a given scenario, ATSA SURF alerts are provided only on up to two levels. This is because, first, in situations of imminent collision risk, immediate flight crew awareness and immediate flight crew response is necessary (i.e., warnings). Second, a precursory caution alert is intended to provide flight crew awareness and in certain cases prepare the flight crew for a warning alert and thereby facilitate the required immediate response. Only one precursory caution alert is needed for this purpose. Advisory alerts are not used in this concept, instead indications are provided, see above. Verification of these conclusions via empirical study is currently outstanding and recommended to be conducted.

The ATSA SURF two-level alerting scheme is similar to the two-level alerting scheme in TCAS II. Consistency between SURF ALERT and TCAS II is considered to be highly desirable due to the implications to crew operations and training.

Alerts are triggered dependent on scenario and are sensitive to various factors that include time to the conflict, ownship operation, movement and position of the conflict aircraft, available flight crew responses, as well as an acceptable degree of uncertainty[7]. Alerts are presented sequentially if more than one alert is provided in a given scenario and they follow indications that were given prior to alerts.

1. Advisories require flight crew awareness and may require subsequent flight crew response. Advisories are not used as ATSA SURF alerts.

2. Cautions require immediate flight crew awareness and require subsequent flight crew response. The flight crew may not respond to the caution by a compensatory response but, for example, acquire additional information before initiating action.

   Presentation principle: Caution alerts are presented unless they would cause unacceptable distraction during high workload and time critical situations. E.g. cautions may be suppressed when the aircraft's speed during the departure roll has reached a speed where the crew has committed to take-off (e.g. above 80 knots).

3. Warnings require immediate flight crew awareness and immediate flight crew response.

   Presentation principle: Warning alerts are presented anytime as they are needed and are only suppressed when providing a warning is associated with a greater hazard than the warning condition itself (e.g. an aborted take-off at high speed may constitute a significant safety risk and therefore.

2.2. Procedures and responsibilities

2.2.1. Air traffic control

At towered airports, ATSA SURF IA equipped aircraft will be under control of local tower and ground controllers. Controller procedures and responsibilities will not change with this

[7] An acceptable degree of uncertainty results in sufficiently low false and missed alert rates while correctly detecting alert events with appropriate latency. Determination of acceptable levels of uncertainty is a subject to research.

application. Air traffic controllers will continue to be responsible for managing traffic under their control to ensure safety and provide operational efficiency. Flight Deck ATSA SURF IAs may or may not be available to the controllers. If available, this information may, similar to TCAS, be provided to controllers via downlink. This TCAS downlink capability, though technically feasible, has not been operationally implemented in current day operations. In towers where ground-based runway safety surveillance and warning systems have been installed, controllers will continue to use existing runway safety tools to identify and resolve runway safety conflicts. ATSA SURF IA information is expected to complement, not replace, existing ATC procedures and systems. Flight crews will communicate with controllers if deviating from their cleared route as they do in today's environment (e.g. communication of pilot initiated go-around). ATSA SURF alerts may cause maneuvers that will require prior or subsequent coordination with air traffic control.
ATSA SURF IAs will also be available at non-towered airports.

2.2.1.1. Proposed new pilot-controller phraseology

Current phraseology will be used for the proposed operations. No new phraseology is foreseen to be needed.

2.2.1.2. Aircraft separation / spacing criteria

There is no change in aircraft separation minima for this application.

2.2.2. Pilots

No changes in the basic responsibilities for pilots, including separation responsibility, are required. ATSA SURF IA capability status will be determined during checklist completion for departure and arrival. ATSA SURF IA is enabled but displays and annunciations are suppressed prior to the aircraft approaching the active movement area during arrival or taxiing for departure.

When the ATSA SURF IA application provides an indication or alert, the pilot(s) determine what, if any, action is required to ensure continued safe operations.

It needs to be determined what information ATSA SURF IA's will contain. For example, it needs to be determined if a subset of ATSA SURF IA alerts will provide resolution advisories.

Flight crews will be trained for mixed equipage situations where not all aircraft will be monitored by the ATSA SURF IA application. This may be either due to lack of equipage, or inoperative equipment. As under current operations, unequipped aircraft may only be acquired visually. The flight crew continues to scan outside the cockpit as under current operations. Specifically, in mixed equipage situations, the absence of an indication or alert is no assurance that the path ahead is clear – i.e., no guarantee that there is no potential or actual traffic conflict.

2.2.3. Other Responsibilities

There are no new Airline, Flight Service Station, or other responsibilities associated with ATSA SURF IA.

3. Sample scenarios

TBD

4. Requirements

This section is in an early stage of the development and will receive significant refinement during the concept maturation.

4.1. Functional Performance Requirements

ATSA SURF alerts and indications will need to be below thresholds for acceptable rates of missed, false, and nuisance alerts. Acceptable thresholds will be established as part of a safety analysis and described in later versions of this document.

4.2. Functional Display Requirements

ATSA SURF indications and alerts are provided as a supplement and complement to surface traffic displays where they are available. Alert indicators provide information to flight crews about runway safety relevant information and complement existing displays, ie. flight crew responses to runway safety hazards may be initiated solely upon ATSA SURF alerting. ATSA SURF indications are intended to supplement existing displays and be used in addition to existing displays. These indications are not intended to cause flight crew responses by themselves. The implementation of ATSA SURF IAs will depend on the aircraft type specific flight deck display implementations to achieve overall consistency. There exist significant differences in how e.g. visual and auditory attention getters are utilized in different aircraft types. Therefore, the present listing of functional requirements here (see Table 2) provides only general guidance for implementation. Three sets of functional display requirements are differentiated: one with CDTI, one without a CDTI, and one where ATSA SURF IA is decoupled from the CDTI.

Table 2 Presentation Requirements

	Implementation with CDTI	**Implementation without CDTI**	**Decoupled CDTI**
Indication	Presentation Intent: Provide situation awareness about runway safety and traffic status.		
	Presented information: • Visual graphical (may be accompanied with alphanumeric) information. • i.e., no visual or auditory* "attention getting" information except in specific scenarios such as ownship approaching a runway on which a conflict is being predicted.	Presented information (at least one of the three): • Visual "attention getting" cue in primary field of vision or • Visual graphical or alphanumeric information or • Auditory speech or auditory non-speech information	Same as "implementation without CDTI"

Advisory	***Not used in the current implementation*** *Presentation Intent:* *Provide timely flight crew awareness.*		
	Presented information: • Visual (graphical and alphanumeric) information on CDTI	Presented information: • Visual information to facilitate flight crew understanding of the condition	Same as “implementation without CDTI”
Caution	Presentation Intent: Provide immediate crew awareness and subsequent response.		
	Presented information: • Visual “attention getting” cue in primary field of vision and • Aural auditory “attention getting” cue (voice, tone or both) and • Visual (graphical and alphanumeric) information on CDTI	Presented information: • Visual “attention getting” cue in primary field of vision and • Auditory “attention getting” cue (voice, tone, or both) and • supplementary information to facilitate flight crew understanding of the condition if not already provided.	Same as “implementation without CDTI”
Warning	Presentation Intent: Provide immediate crew awareness and immediate proper response.		
	Presented information: • Visual “attention getting” cue in primary field of vision and • Aural auditory “attention getting” cue (voice, tone or both) and • Visual (graphical and alphanumeric) information on CDTI • Visual (graphical and alphanumeric) information on CDTI.	Presented information: • Visual “attention getting” cue in primary field of vision and • Auditory “attention getting” cue (voice, tone, or both) and • Supplementary information to facilitate flight crew understanding of the condition if not already provided.	Same as “implementation without CDTI”

Note: *The term “auditory” refers to speech as well as non-speech elements (e.g. tones).

The presentation of ATSA SURF IAs should be consistent with existing traffic alerting, specifically for TCAS equipped aircraft. Therefore, TCAS alerting requirements are displayed in Table 3 as outlined in FAA (2001).

Table 3 Specification of TCAS Alerting

Ownship	Resolution Advisory (RA)	Traffic Advisory (TA)	Display Traffic
Above 1000 feet (+/- 100) AGL*	*Visual and auditory component*	*Visual and auditory component*	*Yes*
At or below 1000 feet (+/- 100) and above 500 (+/- 100) AGL	No	Visual and auditory component	Yes

At or below 500 (+/- 100)	No	Visual with**out** auditory component	Yes

*ATSA SURF IA does not provide alerts above 1000 feet AGL.

4.3. Infrastructure Requirements

4.3.1. Ground / ATC

Ground infrastructure will be required to assure adequate surface coverage and to provide ATSA SURF IA capability for ADS-B dual links for Universal Access Transceivers (UAT) and Mode S extended squitters (1090ES) transponders[8]. Specifically, there may be a need to provide one or more ADS-B Ground Based Transceivers (GBTs) to allow communication between aircraft equipped with different radio frequency ADS-B transponders to see each other. The ADS-B surface environment is depicted in Figure 2 and consists of one or more ADS-B ground stations capable of receiving and retransmitting both 1090ES and UAT. Other surveillance sources beside ADS-B are provided as Traffic Information Service – Broadcast (TIS-B) uplink through the ADS-B ground station. The ground control facility would provide a tracker to minimize the retransmission of redundant traffic from ADS-B and radar-derived TIS-B. Finally, ground-based capabilities may be used to confirm on-board alert settings such as runway closures.

At airports where the outlined ground infrastructure does not exist and where some aircraft are not ADS-B OUT equipped, the effectiveness of the alerting capability will be diminished because no alerting can be provided about non- ADS-B OUT equipped aircraft.

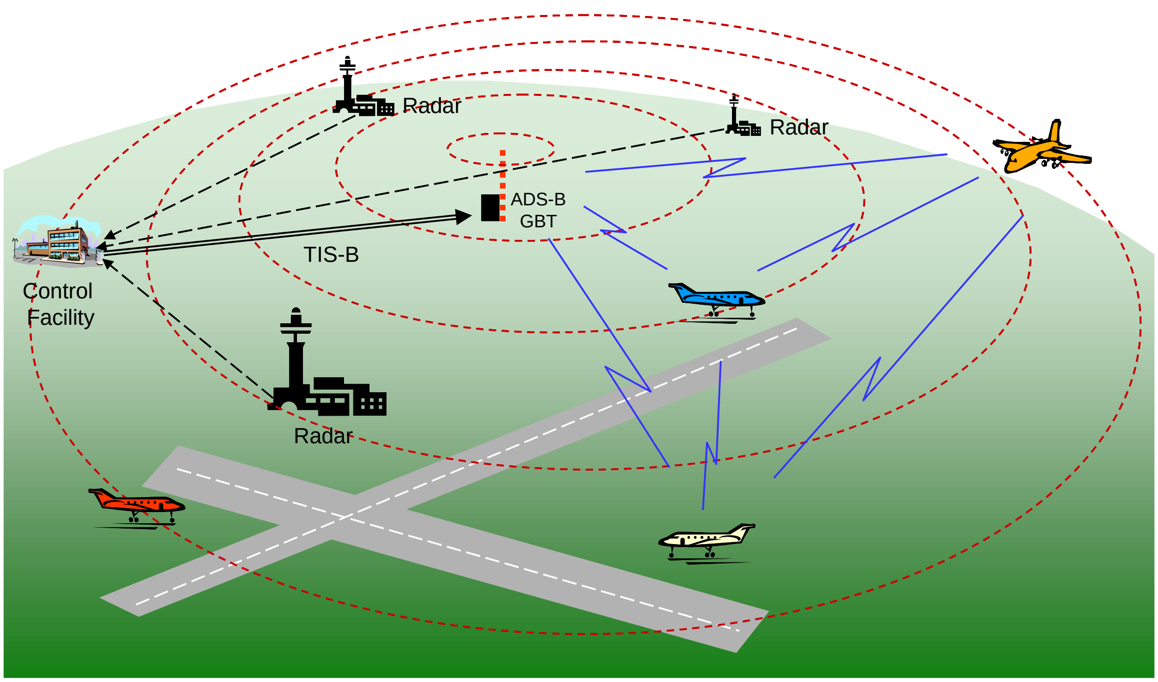

Figure 2 ADS-B Surface Environment

[8] UAT and 1090ES are two different data link systems on board of aircraft to send and receive ADS-B data.

This configuration allows aircraft near the surface on approach or departure as well as aircraft on the airport surface to communicate via ADS-B. Ground surveillance requirements are, for example, listed in RTCA (1999).

TCAS has a capability to downlink resolution advisories (RA) to ATC. ATSA SURF IA may reuse this or another to-be-specified-downlink capability to broadcast alerts to controllers. Downlink information requirements need to be defined. Changes to current industry requirements may need to be made to reflect the new ATSA SURF IA capabilities. For ATC to be informed of the RA/ATSA SURF IA indication, ATC ground automation would have to be modified to accept this indication and properly communicate it to ATC personnel. This capability requires further operational definition and specification and represents an existing development issue and is beyond the scope of this document.

4.3.2. Aircraft

The ATSA SURF IA capability will require the flight deck be equipped with ADS-B IN[9] and OUT[10] as defined in the FAA ADS-B surveillance requirements (FAA 2007b). This will allow the aircraft to receive ADS-B transmissions from other aircraft in the ATSA SURF IA operational area and also provide own-ship position transmissions to all other local aircraft. The aircraft will also need to be equipped with a system that can host the ATSA SURF IA logic, airport surface map database and the ability to provide that information to the ATSA SURF IA logic. The ATSA SURF IA system will also provide the necessary interfaces to the aircraft audio system and to a moving map display if available.

[9] ADS-B IN is considered the ability for the aircraft ADS-B system to receive and display ADS-B from other traffic aircraft.

[10] ADS-B OUT is considered the aircraft capability to generate and transmit industry standard ADS-B messages based on the ADS-B technology installed in the aircraft.

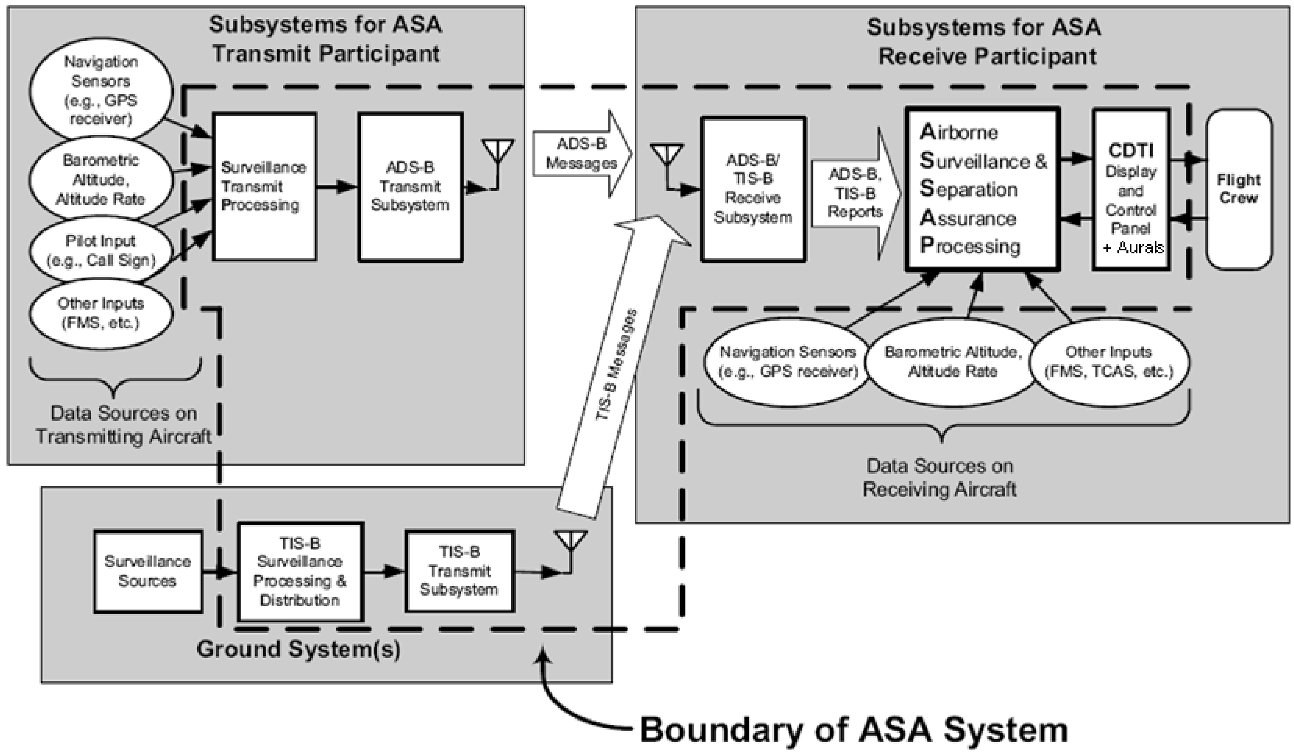

Figure 3 Example for ATSA SURF IA Systems Architecture including a CDTI Display.

Figure 3 shows a generic systems architecture for ATSA SURF IA from RTCA (2006) that includes a CDTI display. Alternative systems architectures exist. In this architecture, the warning logic is a new capability and part of the Airborne Surveillance Separation Assurance Processing (ASSAP). Nevertheless, a map and traffic display is desired, but is not strictly required. A performance analysis will be performed to determine technical requirements for these capabilities.

4.3.3. Airlines Operations Center & Flight Service Stations

It is not expected that any new infrastructure is needed at Airlines Operations Centers or the Flight Service Stations to provide direct cockpit warning support.

5. Training and Maintenance requirements

TBD

6. Other Considerations

ATSA SURF IA provides traffic indications and alerts. Other runway safety risk areas exist such as deviations from controller cleared taxi routes, runway status (e.g., closed) and obstructions (e.g., construction areas or equipment), take-off or landing on too short runways, on unauthorized runways, or on taxiways, etc. Indications and alerting that addresses these types of surface safety hazards must be consistent and compatible with ATSA SURF IA indications and alerting.

6.1. Relationship to other programs and future enhancements

TBD

6.2. Other issues

1. Will ATSA SURF IA warning messages contain commands to pilots or only provide information?

    - Issue: ATSA SURF IA warnings are conceptualized to be similar to TCAS resolution advisories which do provide obligatory commands to pilots. However, it is not clear if, and under what conditions commands could be given to flight crews under the airport surface operations. For example, the decision about a take-off abort may involve consequences that automation cannot sufficiently consider under all possible circumstances. Therefore, pilots may need to make this decision. There may, however, be situations when an automation could provide a command.

    - Resolution Method: discussion, human in the loop simulation
    - Status: open
    - Resolution: TBD

2. What are acceptable rates for false and missed alerts?
    - Issue: False alerts have shown to generally decrease trust of users into their task and are associated with decreased likelihood or delay of operator response to the alert (see Bliss & Fallon, 2006). False and missed alerts may also increase the operators workload. Therefore, false and missed alerts are undesirable design features and will need to be quantified.
    - Resolution Method: Empirical study, literature review
    - Status: open
    - Resolution: TBD

3. To what extent should auditory information be used for advisory level alerts?
    - Issue: The provision of auditory information for advisory alerts is not clearly regulated by AC. The AC simply states that advisory alerts do not require visual or aural features. Also, generally, advisory alerts are not associated with aural information, instead caution or warning level alerts are provided. It is not clear if visual / aural features may cause problems for flight crews, e.g. nuisance. Specific questions are: Will non-auditory information provide sufficiently timely flight crew awareness? Will in turn, in cases when no flight crew response is required, auditory information cause undue distraction to the flight crew? Under what conditions/scenarios may auditory information be required?
    - Resolution Method: Empirical study, group consensus
    - Status: open
    - Resolution: TBD

4. To what extent should auditory information be used for ATSA SURF indications?

- Issue: The provision of auditory information for ATSA SURF indications may result in overloading the auditory channel of pilots during normal operational conditions. However, in some situations, where alerting quality may not be sufficient, indications with auditory annunciators may be the only way to provide relevant information to the flight crew. Therefore, the disadvantages of auditory annunciations with ATSA SURF indications needs to be determined.
- Resolution Method: Empirical study, group consensus
- Status: open
- Resolution: TBD

5. What is the appropriate principle for the presentation of indications?
   - Issue: Two principles are differentiated: a basic principle and a context dependent principle. Which of the two principles is more effective?
   - Resolution Method: Empirical study
   - Status: open
   - Resolution: TBD

6. Are ATSA SURF alerts provided to ATC?
   - Issue: An alert that is provided on the flight deck may cause the flight crew to initiate a maneuver that is unexpected by ATC, e.g. a go-around. Providing the alert automatically also to ATC may benefit ATC in assessing their situation. Is it required to downlink ATSA SURF alerts to ATC?
   - Resolution Method: Group consensus
   - Status: open
   - Resolution: TBD

7. Issues that are outside the scope ot this application:

Following issues have been repeatedly discussed as part of this application development but found to be outside the initial scope of this application:

1. Alerting and indications about potential collisions in airport ramps areas.
2. Alerting and indications about potential collisions on airport taxiways.
3. Integration between ground based alerting logic and flight deck based alerting logic.[11]
4. Surveillance accuracy requirements will not be part of this application description.
5. Alerts and indications only account for traffic and do not consider non-traffic targets such as deer or snow ploughs without ADS-B transmitter.

8. Definitions

Advisory The level of alert for conditions that require flight crew awareness and may require subsequent flight crew response. Advisories may or may not contain an auditory message. Advisories are associated with any color but red or green and preferably not yellow/amber (FAA 2007a).

[11] The ATSA SURF IA application will be consistent with ground based alerting but not rely on the provision of ground based safety information as essential component.

Alerts	The term alert is here used as a generic term to describe a flight deck annunciation[12], meant to attract the attention of, and identify to the flight crew a non-normal operational or airplane system condition. Warnings, Cautions, and Advisories are considered to be alerts. (FAA 2007a)
Attention Getting Cues	Perceptual signals (visual, auditory or tactile/haptic) designed to attract the flight crew's attention in order to obtain the immediate awareness about an alert condition.
Auditory signals	Are speech signals that contain human or artificial verbal signals, or non-speech signals that contain either tonal signals (single or multiple tones) or auditory icons (invoking high level of association with signal meaning)
Caution	The level of alert for conditions that require immediate flight crew awareness and subsequent flight crew response. Cautions are associated with an auditory signal and the color yellow/amber.
Departure	An aircraft is accelerating and has reached a nominal speed, e.g. 35 knots.
Entering Runway Conflict	Entering the runway: An aircraft or vehicle is moving toward the runway, is anticipated to potentially enter the runway, and therefore causes a potential conflict.
False Alert	An incorrect or spurious alert caused by a failure of the alerting system including the sensor.
Indications	ATSA SURF indications are here used to identify to the flight crew a normal operational condition that could become a runway safety hazard. Indications do not actively attract attention from flight crews but provide enhanced situation relevant information to facilitate flight crew perception of potential safety hazards. Indications are not alerts.
Landing	An aircraft has touched down and is moving at a speed above taxispeed, e.g., 35 knots.
Master Aural Alert	An aural indication used to attract the flight crew's attention that is specific to an alert urgency level (e.g. Warning, Caution)
Master Visual Alert	A visual indication used to attract the flight crew's attention that is specific to an alert urgency level (e.g. Warning, Caution).
Missed Alert	Condition where, due to a system failure, an alert should, but is not generated.

[12] The AC 25.1322 uses here the term "indication". This term is changed here to allow differentiation from the term "indication" that is here used specifically as defined above.

Normal Condition	An operational condition or state within acceptably safe parameters for the prevailing environmental and traffic conditions at an airport.
Nuisance Alert	An alert generated by a system that is functioning as designed but which is inappropriate or unnecessary for the particular condition.
Runway in use	A runway is called in use when an aircraft is currently moving on that runway or is predicted to be moving on that runway at high speed (e.g. above 35 knots).
Runway Occupied	A runway is called occupied when an aircraft is currently stopped on that runway or is moving on that runway at low speed (e.g. at or below 35 knots).
Takeoff	See departure.
Warning	The level of alert for conditions that require immediate flight crew awareness and immediate flight crew response. Warnings are associated with an auditory signal and the color red.

9. References

Adam, G., Kelley, D., Steinbacher, J. G. (1994). Reports by Airline Pilots on Airport Surface Operations: Part 1. Identified Problems and Proposed Solutions for Surface Navigation and Communications. MITRE MTR 94W0000060.

Adam, G., Kelley, D., (1996). Reports by Airline Pilots on Airport Surface Operations: Part 2. Identified Problems and Proposed Solutions for Surface Operational Procedures and Factors Affecting Pilot Performance. MITRE MTR 94W0000060.v2.

Bales, R. A., Gilligan, M. R., & King, S. G. (1989). An Analysis of ATC-Related Runway Incursions, with Some Potential Technological Solutions. MITRE MTR-89W00021.

Bliss, J. P. & Fallon C. K. (2006). Active Warnings: False Alarms. In M. S. Wogalter (Ed.) Handbook of Warnings, pp. 231 - 242. Lawrence Erlbaum Associates: Mahwah, NJ.

Cardosi, K., & Yost, A., 2001, Controller and Pilot Error in Airport Operations: A Review of Previous Research and Analysis of Safety Data, U.S. Departure of Transportation, Federal Aviation Administration, DOT/FAA/AR-00/51.

Cassell, R,. Evers, C., & Esche, J. (2003). Safety Benefits of PathProx – A Runway Incursion Alerting System. Proceedings of the Digital Avionics Conference 2003, V(22), 9.B.4-1 – 10.

Federal Aviation Administration’s Runway Incursion Program Office (ATO-102) (1998), *1998 Airport Surface Operations Safety Action Plan to Prevent Runway Incursions and Improve Operations*, U.S. Department of Transportation.

Federal Aviation Administration (2001). Air Carrier Operational Approval and Use of TCAS II. AC 120-55B. Department of Transportation, Federal Aviation Administration.

Federal Aviation Administration (2003a). Advisory Circular 120-74A Guidelines to standardize Flight Crew Procedures during Taxi Operations, Department of Transportation, Federal Aviation Administration.

Federal Aviation Administration (2003b). Advisory Circular 91-73 Single Pilot Procedures During Taxi Operations, Department of Transportation, Federal Aviation Administration.

Federal Aviation Administration (2005a). Runway Safety Report. Department of Transportation: Washington, DC.

Federal Aviation Administration (2005b). AMASS Specifications, FAA-E-2069a.

Federal Aviation Administration (2006a). *Design and Installation Details for Airport Visual Aids*, Advisory Circular 150/5340-1J.

Federal Aviation Administration (2006b). ASDE-X Interface Control Document, NAS-IC-24032410-xx.

Federal Aviation Administration (2007a). Runway Status Light Engineering Briefing 64a.

Federal Aviation Administration (2007b). Automatic Dependent Surveillance Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service, Notice of Proposed Rulemaking. Department of Transportation, RIN 2120-AI92: Washington, DC.

Federal Aviation Administration (2007c). Advisory Circular 25.1322 Flight Crew Alerting, Department of Transportation: Washington, DC.

Cassell, R., Evers, C., Esche, J., & Sleep, B. (2002). NASA Runway Incursion Prevention System (RIPS) Dallas-Fort Worth Demonstration Performance Analysis. NASA / CR-2002-211677.

Hooey, B. L., Foyle, D. C., Andre, A. D., & Parke, B. (2000). Integrating datalink and cockpit display technologies into current and future taxi operations. Proceedings of the AIAA/IEEE/SAE 19th Digital Avionics System Conference, 7.D.2-1 - 7.D.2-8. Philadelphia, PA.

Hooey, B.L., Foyle, D.C. and Andre, A.D. (2000). Integration of Cockpit Displays for Surface Operations: The Final Stage of a Human-Centered Design Approach. SAE Transactions: Journal of Aerospace, 109, 1053-1065.

Hyer, P. V. (2002). Demonstration of Land and Hold Short Technology at the Dallas-Fort Worth International Airport. NASA / CR-2002-211642.

IFATCA (2003). A-SMGCS Implementation in Europe. Publication of the International Federation of Air Traffic Controllers' Associations.

Jones, D. (2002). Runway Incursion Prevention System Simulation Evaluation. Presented at the 21st Digital Avionics Systems Conference.

Jones, D. (2005). Runway incursion prevention system testing at the Wallops Flight Facility. Presented at the SPIE Defense & Security Symposium, Orlando, FL, March 28, 2005.

Jones, D. & Prinzel, L. J. (2006). Runway Incursion Prevention for General Aviation Operations. Presented at the 25th Digital Avionics Systems Conference.

Jones, D. R., Quach, C. C., & Young, S. D. (2001). Runway Incursion Prevention System – Demonstration and Testing at the Dallas/Fort Worth International Airport. Presented at the 20st Digital Avionics Systems Conference.

National Transportation Safety Board, 2000, Safety Recommendation to the FAA, A-00-66, Washington, DC.

RFG (2006). Enhanced Traffic Situational Awareness on the Airport Surface (ATSA-SURF).RFG internal document v. 1.9.

RTCA (1999). The Role of GNSS in Supporting Airport Surface Operations. Document Number RTCA/DO-247. RTCA: Washington DC.

RTCA (2003). Minimum Aviation System Performance Standards for Aircraft Surveillance Applications (ASA), DO-289. RTCA: Washington DC.

Steinbacher J. G. (1991) An Analysis of ATC-Related Runway Incursions in the National Airspace. MITRE WP 91W00234.

Young, S. D. & Jones, D. R. (2000). Runway Incursion Prevention Using an Advanced Surface Movement Guidance and Control System (A-SMGCS). Presented at the 19th Digital Avionics Systems Conference.

Young, Steven D.; and Jones, Denise R. (2001): Runway Incursion Prevention: A Technology Solution. Proceedings of the Flight Safety Foundation 54th Annual International Air Safety Seminar, Athens, Greece, Nov. 5 – 8, 2001.

10. Acronyms

AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance – Broadcast
AGL	Above Ground Level
AMASS	Airport Movement Area Safety System
ASDE-X	Airport Surface Detection Equipment – Model X
ASSA	Airport Surface Situational Awareness
ATC	Air Traffic Control
ATSA SURF IA	Enhanced Traffic Situational Awareness on the Airport Surface with Indications and Alerts
CDTI	Cockpit Display of Traffic Information
DFW	Dallas - Fort Worth International Airport
DVD	Digital Versatile Disc
EAT	End-around Taxiway
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FY	Fiscal Year
GBT	Ground Based Transceiver
GPS	Global Positioning System
FAROA	Final Approach and Runway Occupancy Awareness
ICAO	International Civil Aviation Organization
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
REL	Runway Entrance Lights
RFG	Requirements Focus Group
RA	Resolution Advisory
RI	Runway Incursion
RIIEP	Runway Incursion Information Evaluation Program
RTCA	Radio Technical Commission for Aeronautics (as introuced in 1935)
SAN	San Diego International Airport
SC	Special Committee
TA	Traffic Advisory
TCAS	Traffic Alert and Collision Avoidance System
THL	Take-off Hold Lights
TIS-B	Traffic Information Service - Broadcast
UAT	Universal Access Transceiver
US	United States